SOUND EMBODIED: EXPLORATIONS OF SONIC INTERACTION DESIGN FOR EVERYDAY OBJECTS IN A WORKSHOP SETTING

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ABSTRACT

We describe an emergent field of considerable relevance to the auditory display community – that of sonic interaction design for everyday artifacts. It is positioned at the intersection of auditory display, product interaction design, and ubiquitous computing. We describe an exploration of this field that we have undertaken in a workshop setting, with an international mix of designers, students and researchers, aimed at investigating new roles for auditory display in everyday products, and possible methodologies for designing them. In this paper, we define sonic interaction design, describe the outcome of this workshop, which has been planned as the first in a series, and indicate future directions. We point to new research initiatives, including the European project CLOSED (Closing the Loop of Sound Evaluation and Design), which aims at providing new tools that are needed by designers working in this emerging field.

1. INTRODUCTION

Sonic interaction design is a new discipline that concerns the use of sound as one of the principal channels conveying information, meaning, and otherwise affecting the experience of interactive artifacts or systems. It consists notably of research in interactive sonification, which is a familiar subject to the auditory display research community [1], and in addition comprises the investigation of interactive sound in products or other artifacts, and ways in which these sounds may be designed. The current paper is meant to highlight the latter research area and to suggest its relevance to ICAD.

The field has grown in relevance, both as a result of design driven needs, and as economies of scale and miniaturization have contributed to a widening array of everyday artifacts that are embedded with ever more sophisticated sensing and actuating capabilities.

Already a handful of research projects have been initiated to explore this territory, including the former Disappearing Computer initiative of the European Union, and the new European project CLOSED [2], which aims at developing suitable measurement tools and criteria to aid in the design of sound in interactive artifacts. A new European COST Action on Sonic Interaction Design has recently been spawned to coordinate international scientific collaboration on the subject.[1] At the same time, research in this area is in some respects confronted with the need to catch up with practice, as many of the products that could benefit have already reached the market.

The result is that an immense opportunity is emerging for the design of a wider range of auditory displays in everyday artifacts ranging from shoes to intelligent fishing gear. As designers and researchers in auditory display, interaction design, product design, it will be valuable for us to increasingly take note of these opportunities, as they are likely both to influence our practice, and to feed new concepts and challenges back into research in the design and engineering of auditory displays.

Auditory display research to date has gravitated around a number of topics such as the sonification of datasets (interactive or otherwise), auditory feedback in computing displays, auditory icons, earcons, signaling and mobile communication and computing applications [3]. There has been an accompanying increase in awareness of the need for multimodal human computer interfaces, as the contexts in which computing takes place today include many in which an additional visual display may not be effective, or may not be an option (e.g. [4]).

At the same time, despite its success in characterizing, evaluating, and shaping noises emitted by domestic artifacts or equipment [5][6], and their suitability to the function they serve [7], research in product sound quality remains far in relevance from the kinds of knowledge, examples, and tools that product and interaction designers need to be able to respond to the challenge of integrating sound as a significant interactive modality in an already rapidly growing array of products that make use of it.

In this paper, we argue for a strengthening of research at the intersection of auditory display and sonic interaction design for products, based on a set of common goals aimed at satisfying design driven needs for interactive sonification in everyday artifacts, many of which may not possess a visual display at all. Indeed, many of the key motivations and roles [3] that have been described and evaluated in the literature on auditory displays are relevant for sonic interaction design in this setting, including the overload of the visual channel [4], the power of sound to communicate information about a continuous or temporally significant process, to supply ambient information related to a place or activities, or to improve an ongoing continuous control activity, such as a sport [8].

Other issues raised by the consideration of everyday sound augmented artifacts are complementary to those that have been most prominent in the auditory display literature – for example, questions concerning the appropriateness of an object's sound to its environment and soundscape. Moreover, examining the world around us, with notable exceptions, it is typically populated with artifacts that, even when interactive, are frequently lacking any dy-

[1] More information about the COST Action IC0601 on Sonic Interaction Design can be found at `http://www.cost.esf.org/`

namic visual display.

In this context, we conducted the first in what is planned as a series of workshops focused on auditory display for interaction with everyday artifacts. The workshop was held with a group of designers, design students, and an international group of researchers. Our aim has been twofold: To investigate new roles for auditory display in everyday products, embodied by new design concepts and cases uncovered in the field, and to test methodologies that can be applied to their design. A recurrent theme in this dialogue has been the relation between action, task and sound, and this is reflected in a body of evidence that the workshop has collected.

2. SOUND IN PRODUCT INTERACTION DESIGN

Sound design already plays a significant role in many areas of product design, especially those which create products with high functional densities, strong design identities, or which address demanding markets such as luxury goods. Prominent industries that have benefited from it include the automobile and cosmetics industries, but lower profile applications have arisen in other areas, such as kitchen appliances and office equipment.

While sound design in these industries has mainly been concerned with shaping acoustic appearance, establishing identity, and in eliminating "noise", interactive sound can be integrated more deeply with functionality and the interaction process, similar to the role it plays in auditory display. Recent technological advances have enabled new approaches to interaction design, giving rise to applications that link sound in product and industrial design with formerly exotic but now highly active research fields, ranging from personal robotics, to telepresence, mobile music, and global positioning. A number of parallel developments have contributed to the increased relevance of Sonic Interaction Design today. The ubiquitous nature of computing and communication resources has led to the spread of auditory displays to everyday situations, as the appliances that surround us have advanced to the point that they have ample computing power to actively control their interactive auditory appearances. Techniques for the interactive synthesis of sound, including everyday sounds, have advanced so as to provide new ways for auditory displays in products to be seamlessly integrated into activities and to sonically mesh with needs serving diverse sonic environments. Sensors are readily available to make sounds responsive to human activities, providing new functionalities and enhancing existing ones. These advances are already generating products that evidence a deeper integration of sensing and actuating technologies into the functionalities and activities they serve. Examples of already widely distributed products that exploit a tight coupling between sound and gesture in interaction include the Nike+ running shoe and music player system, the scrolling devices on current generation iPods and mice by Apple Inc., and the Nintendo Wii game controller.

Sonic interaction design (SID) can be used to describe practice and inquiry into any of several kinds of roles that sound may play in the interaction loop between users and artifacts, services, or environments. The subject raises a number of areas of inquiry associated to the augmentation of sound in everyday products and activities that have been at the heart of discourses in sound-concerned communities for decades; For example, the link between sound and location, and the ability of an artifact to blend in or contrast with its soundscape, or to provide information or new relations that relate to a place and the people in it [9]. Another relates to the role sound can play in providing information about an activity or process, and thereby in allowing to identify activities occurring in an environment, the people performing them, their levels of skill and mannerisms. Walking sounds represent a well studied example.

Central to the objective of mapping out SID as a field is the identification of parts that sound and auditory display play today in product design, or those that it may be expected to expand to take on in the future. Of particular interest for product design are the uses of auditory displays in the following roles.

Creating or revealing new functionalities in a product:

- By displaying new informational capacities (as in the Nike+ system mentioned above)
- By displaying invisible affordances of a computationally augmented artifact – for example, an everyday object that is linked to a computational process
- By distributing an information load linked to the functionality of a product to senses other than vision [4]

Shaping the sonic appearance of an artifact:

- By improving aesthetic experience and sound quality [7]
- By augmenting emotional aspects of the design [10]
- By enhancing the interplay between material, shape, size and actions

Improving performance and usability in the interaction process:

- By providing feedback to aid users' control over an interface [11], tool, device [12], or physical activity [8]
- By sonifying silent information associated to an action (eg. biofeedback)
- By improving the focus and flow experienced by a user during a task

Furthermore, SID already plays a critical role in *creative applications*, most notably in musical interaction design, which continues to be an area rich in compelling application concepts. In harmony with current trends in the design of new musical instruments, we may consider the act of endowing experientially rich sonic qualities to everyday products as one carrying significant creative and artistic potential in itself, and which can be amplified by the complex context and meanings intrinsic to everyday contexts and artifacts [13]. As one example, the project Sonic City consists of an augmented jacket that acts as a musical interface, generating a soundtrack in response to features of the urban environment and the wearer's actions in it [14] .

The field of Sonic Interaction Design, which is in its infancy, will benefit from advances in knowledge in many related disciplines, including the perceptual, cognitive, and emotional study of sonic interactions, improved models for the reception of sound and it's role in performance of actions, adapted design methodologies, sound synthesis technologies and their use, and finally design and evaluation methods addressing the objective and subjective qualities of sounding objects and the interplays between such objects. For a new generation of sound designers to be capable of addressing the interdisciplinary problems the field raises, a more solid foundation of methodologies needs to be developed that can draw on such bodies of knowledge. Sound design as a discipline does not exist today in a form that is capable of meeting the challenges of this emerging field (indeed, some have argued that, with a few notable exceptions, it does not exist at all [2]). The SID workshops we are conducting, which we describe in the following sections, serve as an element in a research process that intends to improve this situation.

3. WORKSHOP DESCRIPTION

The workshop series on SID aims at researching new roles for auditory display in product interaction design, and at exploring related opportunities and use scenarios. Through these we are investigating methodologies for sonic interaction design which can integrate into existing design practices brought by our participants. Our approach is based on learning through experience, in the spirit of Basic Design [15], an approach that originates with the Bauhaus school. Lectures aimed at providing participants with core knowledge and special topics in sound and design are tempered with field research and direct sensory exploration.

Participants are asked both to engage in new modes of listening and to experiment directly with physical materials, artifacts, and digital tools. Specific exercises, such as those described below, have been drawn from design methods that originated in a range of disciplines, including industrial design, ethnographic inquiry and theatre. Some of these serve the role of drawing participants into bodily engagement with the subject, through experience design techniques such as bodystorming [16] (Figure 3). We have planned the workshop series to mesh with activities of the CLOSED project and SID action, in an attempt to integrate our design research and teaching practice with the formation of a group that can be considered to be part of the community the research aims to service. Complementary steps in the same direction will be taken through parallel project-based research practica that will be conducted beginning in the summer of 2007. We describe the process and outcome of the first workshop below.

3.1. Audience and context

The workshop was conducted in the design department of the University of Applied Sciences and Arts in Zurich, Switzerlands largest university for the arts and design, during January, 2007. Participants included fourteen students from the departments of Interaction Design (10), Scenographic Design (3) and Visual Design (1). They were in the third and fourth years of their undergraduate study and arrived with a very heterogeneous level of experience with, and prior exposure to, sound. No more than a quarter of the participants had significant experience with sound design, while another quarter had none. The remaining half had completed a project on setting graphic visualisations to sound, and thus possessed some analytical experience. They were joined by two visiting graduate students in Electronic Music from the Conservatorio di Como, who arrived with a substantial base of knowledge in music technologies and composition, with further participation from researchers from the HGKZ, Ircam, and the University of Verona.

3.2. Workshop activities

The first week of the workshop was structured around lectures and exercises, while the second week focused on the development of short projects of the participants' selection. Throughout both weeks, participants gathered a growing set of sounding objects in the working space – ranging from bells and shakers to bicycle parts and computer hardware – as ready case examples, sources of sonic material and inspiration.

Through the lectures we introduced a variety of topics of significance to the process, including basic concepts and terminology related to sound (notions of sound object, soundscape, and sound source), descriptive frameworks (acousmatic, psychoacoustic, ecological), interaction design methods, the physics and phenomenology of sound, sound synthesis methods, and related ideas from the fields of interaction design and musical interface design.

Figure 1: Interaction design "speed dating" – a fast way to collaboratively generate new ideas.

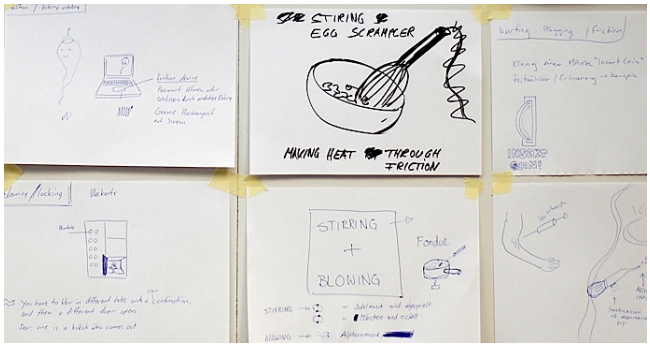

Figure 2: Sketches from the design matrix

An important initial skill for any design activity is the ability to use the senses in question, and to be able to abstract, communicate and conceptualize about the experiences related to them. This was achieved through measures like daily "Ear Cleansing" excercises [17], in which participants were confronted with examples of sound, drawn for example from musique concrète, and were asked to describe what they heard.

3.2.1. Field exercises

A set of field recording and analysis exercises were conducted over the course of the first several days of the first week. These included soundwalks [18], and served to focus the attention of participants onto the complexity of everyday soundscapes and the fact that sounds ultimately occur in a context including other sounds and activities. Participants investigated specific environments, including the train station's ticket purchasing area, an antique store, a canal-side sidewalk, and many others. These initial explorations were followed by more directed assignments in which participants were asked to record, analyze, and discuss case examples of sound produced through human action. This listening permitted facilitated reflection on the nature of sonic patterns that are typical of human action, and to contrast them with automatic or machine-generated patterns.

Figure 3: Bodystorming methods are useful for the fast communication and testing of interaction design ideas.

A more directly comparative approach was taken in exercises directed toward an examination of product sound quality [7]. Participants analyzed and documented interactions with large arrays of products of a given type and typically made of similar materials. Examples included scissors, zippers, industrial buttons, paper, doors and keyboards. Participants were asked to comparatively describe the qualities of the sounds, based on the frameworks that were introduced in the first lectures, and any other terminology they found appropriate (often using terms such as "cheaper", "important", "unstable"), and to present their analyses for discussion.

Based on these discussions, it was apparent that the field exercises significantly heightened participants' sensitivity to sounds in relation to their function and context. The approaches that were employed to understanding and describing sounds seemed to vary significantly between cases in which analysis was performed in the field and when it was accomplished with audiovisual documentation. This seemed not only to be due to the quality of the recorded sounds (which depend critically on microphone technique and other factors), but also to result from the many contextual cues which affect ones perception of the sound cannot easily be recorded. Such features appear nonetheless to be highly relevant for sound design.

In subsequent exercises on sound making, participants explored sounds that they produced through physical performance, as in foley work for film. In a variant on the 2006 Freesound competition,[2] participants were asked to produce sounds characteristic of one of the primordial elements (earth, water, fire or wind), in real time, with the added twist of not being permitted to employ material from the element whose essence they were trying to reproduce. The most successful results depended on surprising combinations, such as the opening of peanuts together with the movement of a large cloth, used as a means of simulating the sound of fire.

The final field exercises that were conducted explored the complex relations between the properties of an object that give rise to its overall experience, as opposed to its sonic qualities alone. Interactive artifacts from an array of environments were identified as case studies, and these were analyzed for sonic properties and for actions composing the experience associated to them. Participants were provided with a range of categories of properties relating to interaction and sound, including: the type of interaction involved (e.g. pouring, cutting, stretching), the configuration of the object (its shape, structure, weight), its surface textures, its material properties (especially in relation to vibrational properties, such as elasticity and density), gestalt features or characteristic patterns in space or time, spatial qualities (spaciousness, closedness, echoes), psychoacoustic and other descriptors. We attempted by means of the set of categories of descriptors to link this activity to earlier lectures devoted to Gaver's and others' work on the categorization of everyday sounds [19]. Participants selected their own subsets of categories and properties to perform these detailed artifact analyses. The results were used as source material for subsequent idea generation stages.

[2]Documented at `http://www.freesound.org`

3.2.2. Design ideation

For each of the cases analyzed in the final field exercise, an interaction process, or set of processes, connecting human and artifact were identified and described. As an alternative to detailed analytic methods such as task analysis [20], a more holistic approach was adopted, founded on Basic Design practices [15]. The analyses proved to be useful means of exploring ways in which sound is connected to action in existing artifacts. Examples of analysed artifacts included a wind-up clock, a train station luggage locker, a bicycle lock, a trash bin, and a tea cup. [3]

The exercise that followed was designed to generate new concepts for auditory display in everyday products through a process of remixing those attributes that had been identified in field analyses. This is an activity that has been successfully used in other international workshops we have participated in, as a means of producing ideas to manifest possible directions in an emerging field [21]. Here, it offered participants an opportunity to engage in rapid, intense ideation sessions in pairs ("interaction design speed dating") with other participants. The aim was to generate an array of new design concepts, and to quickly construct and map an imaginarium representing the future of auditory display, as source material and inspiration for the project phase in the second week. A wall-sized, two dimensional design matrix was created. One axis was enumerated with sonic properties gathered from the prior field analyses, and the other with interaction types. Each descriptor represented the abstraction of a gross characteristic that was determined to be dominant in one of the case studies.

Working in pairs, participants selected an intersection within the matrix, noting the sound and interaction type that met there, and were given ten minutes to generate a design idea based on it (See Figure 1). Participants were left free in their idea generation process, the only constraints arising from the pairing of descriptors, and the time limit. After ten minutes, everyone switched partners, selected another intersection and generated another design sketch together. At each completed step, the sketches were placed back on the wall, ultimately filling it with more than seventy concepts (Figure 2). After this process, participants gathered to present and analyse the results, and to act them out through "bodystorming". A number of the ideas that were produced proved inspirational for our ongoing dialogue around the subject of the workshop, and for the projects of the second week. Examples of the concepts that were created include a fondue set to be augmented with the sound of cowbells and alpenhorns, a sonified livestock insemination tool, to guide the placement of semen, and a carpet that when walked upon would produce characteristic sounds and odors.

[3]A good example of these analyses is documented at this URL: http://sonic.wikispaces.com/AnalysisDelleMonacheFumagalliBugmannLueling

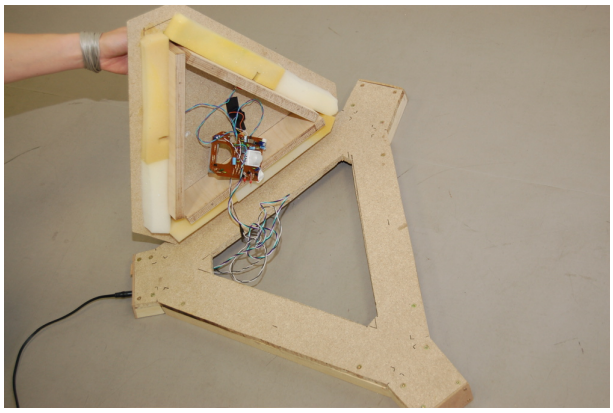

Figure 4: Fast prototyping was used by participants familiar with physical computing (electronics and programming) to execute their projects (here, a sonified jump pad).

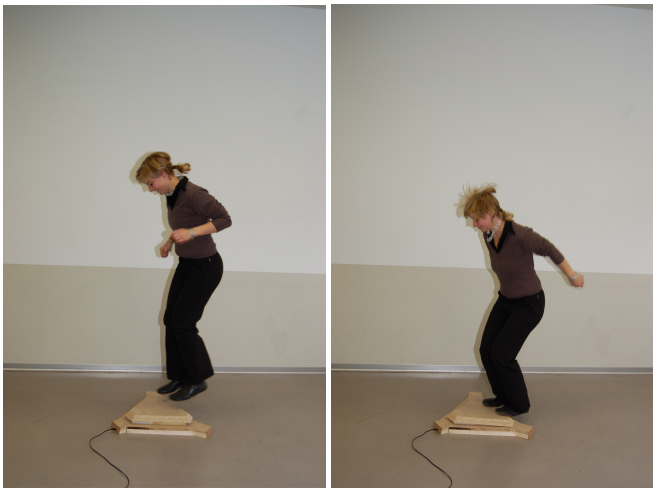

Figure 5: An embodied game artifact, the jump pad from *Game-all-over* (B. Janke) simulates the technology of fantasy in the real world.

3.3. Short projects

Subsequently, participants formed project groups, and their work proceeded in these collectives. Groups employed methodologies and maintained goals that varied according to their interests, to the needs and the backgrounds of their members. Output of the projects ranged from interactive soundmaps of a location that was considered for an urban sonification, to musical compositions oriented around the sonic domain of an interaction design of interest, a number novel product video scenarios, and a few interactive prototypes (Figure 4).

Groups were given feedback from the workshop leaders during discussions that took place on a daily basis. Our practical work during this period was supplemented and enriched by invited lectures from and dialogue with visiting experts in the fields of physical sound modelling (D. Rocchesso, P. Polotti, and S. Pappetti from the University of Verona) and in sound perception (P. Susini and G. Lemaitre from IRCAM).

3.3.1. Project results

Figure 6: Train station lockers were transformed into an emotional or playful experience through sound in the project *Sonic Lockers* (S. Teseo, B. Schuler).

The projects were developed over a compressed, four day schedule. As noted, participants followed varied methodologies, and reached different stages of development in their projects. Due to the deliberately interdisciplinary setting of the course, an effort was made to avoid specifying the nature of the project outcomes beforehand, in order to allow each group to bring their strengths into play, and to observe the range of methods that were employed. Participants addressed wide range of topics through their projects. The projects included:

- *Game-all-over* (Benjamin Janke): Dealt with transformation of exotic virtual artifacts from video game realms – including a jump-pads that can throw the user high into the air – into the real world, via tangible, sonically augmented objects 5.
- *Sonic Lockers* (Stefano Teseo, Barbara Schuler): Investigated the sonic augmentation of lockers in the train station. Interactions such as opening, locking, and closing were lent new, playful symbolism, as they were accompanied by sounds that served variously to exaggerate the weight of the locking mechanism, or to suggest that one's suitcase is being dropped down a fiery chute or is driving away on a tractor (Figure 6).
- *Klingenstrasse* ("Ringing Street", after the name of a street in Zurich. Song Vega, Luisa Beeli). Developed out of an analysis of the spatial and sonic properties of the street Klingenstrasse, this project proposed the sonic enhancement of structural elements such as drains and ventilation openings in buildings, to reflect the activity in the street, and considered the design of sounds produced by patterns over which cars on the street would drive.
- *Thirsty bottle* (Daniel Senn, David Herzog, Johannes Kiesbauer) Aimed to create a sonically augmented bottle that might invite to drink, and enhance both functional and emotional aspects of drinking experience. The bottle, presented in a video scenario, invites one to drink using the sound of

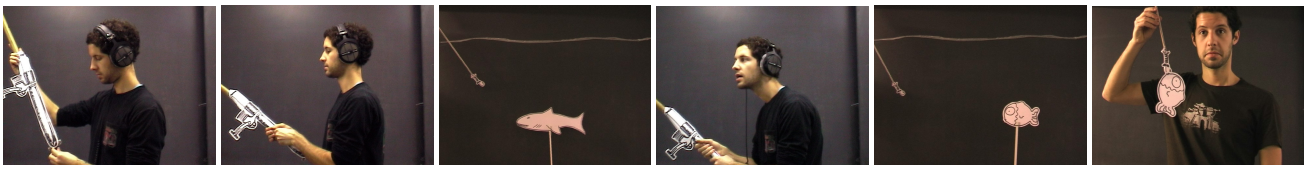

Figure 7: Sonifing the invisible underwater world and the struggle between fisherman and fish, both big and small, in *Sonic Fishing* (M. Tanner, D. Völzke, D. Fischer).

sparkling fluids, and accompanies the drinking with music that might be linked to the beverage or brand.

- *Sonic Fishing* (Marcel Tanner, Daniel Volzke, Daniel Fischer) In Sonic Fishing, a fishing pole augmented is augmented with sound captured underwater that is used to semantically sonify information about the quantity of fish, their size and distance from the hook and bait. The user is equipped with a set of headphones that are connected to the fishing rod. A sensor on the hook, similar to those used in current fish finders, provides the data for sonification. The aim of the project is to improve fishing performance, by displaying proximity to fish, but equally to articulate and amplify the emotional experience – that of having a fish approach or nibble the bait – a process which is otherwise nearly imperceivable. Consideration has also been given to the sonic augmentation of the process of catching and reeling in the fish. Once it has been hooked, the fisherman hears additional information related to the tension in the line between him and the fish, which assists him reeling it in without breaking the line, and provides a soundtrack to accompany the struggle between man and fish. In the development of this project a range of methods including bodystroming were used, and the results were presented in a form of video scenario featuring actors in a fishing performance augmenting with related imagery (Figure 7).

- *Gamelunch* (Stefano Fumagalli, Stefano delle Monache, Stefano Papetti, Simone Lüling) This project focused on sonically enhancing the culturally complex and emotionally rich experience of dining, by making it more playful and performative. The Sonic Dining table accompanies actions performed while eating with a responsive soundtrack 8. Cutlery, dishes and the table surface itself become expressive interfaces. When a plate is moved or a fork is put down, sound is emitted from the table in a playful and changing way. The project explores the transformation of everyday objects and interactions surrounding them into a creative performance and expression. A water pitcher was designed to emit a musical interpretation of a pouring sound, depending on the amount of tilting exerted. The Sonic Dining table was implemented as an interactive prototype, using sensors including contact microphones, wireless accelerometers, a custom designed segmented table surface, and sound synthesis software based on physical sound models developed at the University of Verona. (Figures 8, 9).

These examples evidence a wide range of new roles for auditory display in everyday interactions, and further argue for the potential for extending the focus of research in this area to include a diverse array of contexts and applications.

4. CONCLUSIONS

4.1. Workshop Assessment

Interviews with participants were conducted following the workshop, to gather feedback about the efficacy of the methods used, and to collect further thoughts from the participants summarizing their findings. Some of the conclusions that could be drawn included these:

- Sound design for interaction takes time. Participants, even those with prior experience with sound, are challenged to complete a sonically-dependent scenario or prototype in a compressed period. Significant time is needed for experimentation with sound.
- The subject area is rather complex and interdisciplinary. Even a cursory survey of the theory required is sufficiently complex as to challenge a design-oriented audience. Providing a glossary and reducing expert vocabulary seem like measures that will help.
- On balance, an earlier integration of creative sound design (or sound making) exercises would have been an advantage, as participants like to be able to explore the tools and techniques needed in a trial and error fashion, and want the flexibility to experiment with multiple ideas.

Figure 8: Gastronomy and performance collide via the sonic dining table and sonically augmented water pitcher from *Gamelunch*.

As workshop organizers and researchers in this field, we found this experience further cemented our beliefs that there is a need for new methods capable of assisting designers with the many tasks involved in designing for auditory display in everyday artifacts. Analysis exercises carried out by workshop participants confirmed the fact that the many dimensions of such objects that come into

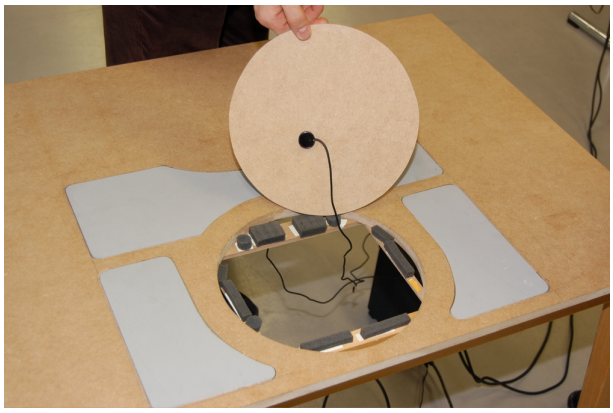

Figure 9: For their project *Gamelunch*, participants constructed a custom sensing scheme based on an acoustically segmented table with contact microphones attached to each segment.
gamelan

play (their appearance, design affordances, sonic qualities, interaction possibilities) seem to demand new approaches to organizing and managing the complex design space they suggest [22]. Physical, sonic, haptic and visual qualities of an artifact and its interactive capabilities are strongly linked, and there is a frequent tendency to describe sound in terms of cross-categorical attributes [23]. One solution that has been suggested is to adopt a fixed lexicon of action categories and terminology to constrain and facilitate such analyses. The need for such categorization and accompanying lexicon for sound designers was described by Ozcan in ICAD 2005 [22]. One goal of the CLOSED project is to take strides toward such a categorization.

Experience with the field exercises that were integrated here suggested that design reflection analysis are strongly context-dependent, and this strongly suggests that such analyses should be carried out in context, when possible. At least in the practice of industrial sound design, this is an uncommon practice. When it is not done, it is clear that many qualities of the experience and its relations to the context are lost. Notions as to the importance of contextual considerations have gained significant attention across other disciplines. As the anthropologist David Howes puts it: "Bringing the issues of emplacement to the fore allows us [researchers] to reposition ourselves in relationship to the sensuous materiality of the world." [24]

Regarding creative research for new products, it is valuable for sonic interaction designers to have some understanding of the sensing and actuating potentials of new technologies in order to use them in their exploratory practices. Until now, such technologies have not been extensively applied in most areas of product sound design, and interaction designers have often had limited training and experience with sound. A further broadening of exposure to such tools is called for on both sides. Collaborations and the exchange of ideas between researchers in auditory display, musical interaction design, and product interaction design seem also to be of substantial value.

4.2. Documentation

As of the writing of this paper, much of the audiovisual documentation for the first workshop, as well as lecture slides and other supplemental materials, may be viewed and downloaded from a dedicated wiki whose URL is:

`http://sonic.wikispaces.com`

More documentation will be placed there in an ongoing way.

4.3. Future Plans

As noted, this is the first in a series of workshops we have planned around this subject. As it has proved to be a revealing and inspirational experience, linking design education, creative ideas for new sonic interaction design concepts, and a wealth of information in the form of documented field cases (several hundred), we are looking forward to future iterations, and to sharing the results, and reflecting on them collectively, with members of the ICAD community.

4.4. Acknowledgments

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5. REFERENCES

[1] T. Hermann and A. Hunt, "Guest editors' introduction: An introduction to interactive sonification," *Multimedia, IEEE*, vol. 12, no. 2, pp. 20–24, 2005.

[2] P. Susini, D. Rocchesso, K. Obermayer, K. Franinović, and Y. Visell et. al., "Closing the loop of sound evaluation and design," in *Proceedings of the ISCA Workshop on Perceptual Quality of Systems*, 2006.

[3] G. Kramer, B. Walker, T. Bonebright, P. Cook, J. Flowers, N. Miner, J. Neuhoff, R. Bargar, S. Barrass, J. Berger, G. Evreinov, W. T. Fitch, M. Grhn, S. Handel, H. Kaper, H. Levkowitz, S. Lodha, B. Shinn-Cunningham ad M. Simoni, and S. Tipei, "Sonification report: Status of the field and research agenda," *Prepared for the National Science Foundation by members of the International Community for Auditory Display*, 1999.

[4] Stephen Brewster, "Overcoming the lack of screen space on mobile computers," *Personal Ubiquitous Comput.*, vol. 6, no. 3, pp. 188–205, 2002.

[5] P.Susini, S. McAdams, S. Winsberg, I. Perry, S. Vieillard, and X. Rodet, "Characterizing the sound quality of air-conditioning noise," *Applied Acoustics*, vol. 65, pp. 763–790, 2004.

[6] James M. Kates, "Classification of background noises for hearing-aid applications," *Journal of the Acoustical Society of America*, vol. 97, no. 1, pp. 461–470, January 1995.

[7] J. Blauert and U. Jekosch, "Sound-quality evaluation – A multi-layered problem," *Acoustica – Acta Acoustica*, vol. 83, no. 5, pp. 747–753, 1997.

[8] A.O. Effenberg, "Movement sonification: Effects on perception and action," *IEEE Multimedia, Special Issue on Interactive Sonification*, vol. 12, no. 2, pp. 53– 59, 2005.

[9] Lalya Gaye, Lars Erik Holmquist, Frauke Behrendt, and Atau Tanaka, "Mobile music technology: report on an emerging community," in *NIME '06: Proceedings of the 2006 conference on New interfaces for musical expression*, Paris, France, France, 2006, pp. 22–25, IRCAM; Centre Pompidou.

[10] Donald A. Norman, *Emotional Design: Why We Love (Or Hate) Everyday Things*, Basic Books, January 2004.

[11] J. Williamson and R. Murray-Smith, "Sonification of probabilistic feedback through granular synthesis," *IEEE Multimedia*, vol. 12, no. 2, pp. 45–52, 2005.

[12] Matthias Rath and Davide Rocchesso, "Continuous sonic feedback from a rolling ball," *IEEE MultiMedia*, vol. 12, no. 2, pp. 60–69, 2005.

[13] K. Franinović and Y. Visell, "New musical interfaces in context: Sonic interaction design in the urban setting," in *NIME '07: Proceedings of the 2007 conference on New interfaces for musical expression*, 2007.

[14] Lalya Gaye, Ramia Maze, and Lars Erik Holmquist, "Sonic city: the urban environment as a musical interface," in *NIME '03: Proceedings of the 2003 conference on New interfaces for musical expression*, Singapore, Singapore, 2003, pp. 109–115, National University of Singapore.

[15] A. Findeli, "Rethinking design education for the 21st century: Theoretical, methodological, and ethical discussion," *Design Issues*, vol. 17, no. 1, pp. 5–17, 2003.

[16] Antti Oulasvirta, Esko Kurvinen, and Tomi Kankainen, "Understanding contexts by being there: case studies in bodystorming," *Personal Ubiquitous Comput.*, vol. 7, no. 2, pp. 125–134, 2003.

[17] Murray Schafer, *Ear Cleaning: Notes for an Experimental Music Course*, Associated Music Publishers, Inc., New York, 1967.

[18] H. Westerkamp, "Soundwalking," *Sound Heritage*, vol. 3, no. 4, 1974.

[19] W. W. Gaver, "How Do We Hear in the World? Explorations in Ecological Acoustics," *Ecological Psychology*, vol. 5, no. 4, pp. 285–313, Apr. 1993.

[20] D. Diaper, "Understanding task analysis for human-computer interaction," in *The Handbook of Task Analysis for Human-Computer Interaction*, D. Diaper and N.A. Stanton, Eds., pp. 5–47. Lawrence Erlbaum Associates, 2003.

[21] Eric Paulos, Ken Anderson, Michele Chang, and Anthony Burke, "Metapolis and urban life," in *Proceedings of the 2005 conference on Ubiquitous Computing*, 2005.

[22] E. Ozcan and R. Van Egmond, "Characterizing descriptions of product sounds," in *Proceedings of the 11th International Conference on Auditory Display*, 2005.

[23] D. Rocchesso, R. Bresin, and M. Fernstrom, "Sounding objects," *Multimedia, IEEE*, vol. 10, no. 2, pp. 42–52, 2003.

[24] David Howes, "Introduction: Empires of the Senses," in *Empire of the Senses – The Sensual Culture Reader*, David Howes, Ed., pp. 1–20C. Berg, Oxford, New York, 2005.